

REMARKS/ARGUMENTS

The Applicants have carefully considered this application in connection with the Examiner's Action and respectfully request reconsideration of this application in view of the foregoing amendment and the following remarks. In the present response, Claims 1, 12, 18, and 24 have been amended. These amendments should not necessitate a new search because the subject matter added to independent Claims 1, 12, 24, previously appeared in dependent Claim 18 submitted with the original application. Accordingly, Claims 1, 4-12 and 15-24 are currently pending in the application.

I. Rejection of Claims 1, 4-12, 15- 24 under 35 U.S.C. §103

The Examiner has rejected Claims 1, 5-6, 8-12, 16-17 and 19-24 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,591,671 to Kim *et al.* ("Kim") in view of U.S. Patent No. 5,714,418 to Bai *et al.* ("Bai"). The Examiner further rejected Claims 4 and 15 under 35 U.S.C. §103(a) as being unpatentable over Kim in view of Bai and further in view of the Applicant's admitted prior art. The Examiner also rejected Claims 7 and 18 under 35 U.S.C. §103(a) as being unpatentable over Kim in view of Bai and further in view U.S. Patent No. 5,970,374 to Teo ("Teo").

Although the Applicants appreciate the removal of the reference: U.S. Patent No. 5,591,671, to McTeer ("McTeer"), it is surprising to see the combination of Kim in view Bai again being cited against the claims of the present invention. The Applicants note that in the Examiner's Action mailed April 19, 2002, this same combination was cited, and then removed, following the Applicant's arguments that this combination failed to establish a *prima facie* case of obviousness

because it did not teach or suggest all elements of the independent claims, and was an improper combination. In fact, the Examiner is on the record in subsequent Offices Actions as stating that the combination of Kim in view of Bai fails to teach subjecting the contact plug to a temperature sufficient to anneal the barrier layer, subsequent to forming the plug (Examiner's Office Actions mailed June 11 and January 3, 2003). Moreover, in the present Office Action the Examiner has made no argument that this element is taught or suggested by the combination of Kim in view of Bai.

The Applicants therefore reiterate that the claimed invention is not obvious in view of the foregoing combined references, and that various combinations of these references fail to establish a *prima facie* case of obviousness of Claims 1, 5-6, 8-12, 16-17 and 19-24 .

Analogous to that pointed out in the June 19, 2002 response to the Examiner's Action mailed April 19, 2002, the combination of Kim in view of Bai fails to teach or suggest all elements of the claimed inventions and thus fail to establish a *prima facie* case of obviousness. For instance, Kim fails to teach or suggest subjecting the contact plug to a temperature from about 600°C to about 750°C to anneal the barrier layer, as recited in Claim 1. Rather, Kim states that heat treatment is performed *after* forming the refractory metal 28 on barrier layer 27. (Column 5, Lines 15-16). Kim does this so that oxidation of the barrier layer and ohmic contact layer can be prevented, thereby preventing the deterioration of the contacting resistance property. (Column 5, Lines 17-18).

Bai fails to cure the deficit teachings of Kim. For example, after forming capture layer 43 and blocking layer 42, but before depositing copper, Bai subjects these barrier layers to a high temperature anneal. (Column 8, Lines 58-64). Bai does this to anneal micro defects in the barrier layers so that the barrier layers can more effectively prevent diffusion of Copper atoms into the

device (Column 8, Lines 63-65; Column 3, Lines 56-66). Performing a thermal annealing step *after* the deposition of metal, as done by Kim, would therefore be contrary to Bai's goal of annealing micro defects in the barrier *before* depositing metal on the barrier. Later, Bai performs CMP to remove the copper layer 44, blocking layer 42 and capturing layer 43 from the upper surface of the dielectric. But there is no suggestion of performing a thermal anneal after the CMP step. Therefore, the combination of Kim and Bai fail to teach or suggest subjecting the contact plug to a temperature from about 600°C to about 750°C to anneal the barrier layer, as recited in Claim 1 and other independent claims.

Moreover, similar to that pointed out in the April 7, 2003 response to the Examiner's Action mailed January 3, 2003, the combination of Kim in view of Bai fails to establish a *prima facie* case of obviousness because the combination is improper. The combination is improper because one of ordinary skill in the art would have no motivation to find or add to Kim the teachings and suggestions of Bai.

The Examiner asserts that Bai teaches extending the plug to an uppermost surface of the substrate, and that Bai is properly combinable with Kim because Bai would result in a planarized interconnect with reduced contact resistance and improved performance of the circuit (Examiner's Detailed Action, Page 3 Lines 7-16). The Applicants respectfully disagree that there is motivation to combine the above-described teachings of Bai with Kim.

The text of Bai cited by the Examiner (Columns 9, Lines 26-42) makes clear that the reduced contact resistance associated with the electrical interconnect of FIGURE 4D is due to the larger cross-sectional area of the interconnect as compared to prior art interconnects (FIGURE 2). The greater cross-sectional area of the interconnect is due to Bai's use of a thin diffusion barrier as

compared to the prior art (Column 2 Lines 56-64; Column 8, Lines 48-57). There is no teaching or suggestion whatsoever that extending the interconnect to an uppermost surface of the substrate has anything to do with asserted advantages of Bai's invention. Therefore, because one of ordinary skill would have no motive to combine Bai's interconnect with Kim, this combination is improper.

Additionally, similar to that pointed out in the June 19, 2002 response, the combination of Kim with Bai is improper because a person having ordinary skill in the art would not be motivated to find or add to Kim the teachings and suggestions of Bai, and Bai would likely destroy the functionality of Kim's device. Kim addresses the problem of preventing oxidation of barrier and ohmic contact layers by depositing a refractory metal layer over the barrier and ohmic contact layers prior to heat treatment. In contrast, Bai is not concerned with the oxidation of his capturing and blocking layer. Rather, Bai wishes to cure micro defects in his barrier so that Copper atoms will not diffuse through the barrier. It follows, therefore, that there would be no motive to insert Bai's step of annealing the barrier layers prior to depositing the metal because this step would run contrary to Kim's goal of preventing oxidation of the barrier layer and ohmic contact layer. Rather, Bai's step would likely destroy the functionality of Kim's device, because this would allow oxidation of the barrier and ohmic contact layers.

Teo also fails to cure the deficit teachings of Kim or Bai. The Examiner cites Teo merely for the proposition of teaching rapid thermal annealing. Teo, however, performs thermal annealing after the deposition of a Ti layer 16 and a TiW layer 18 (Column 4, Lines 17-25; FIG. 3A), but *before* the deposition of tungsten 40. (Column 5, Lines 3-8; FIG. 3E) Thus, Teo's process falls within the scope of Prior Art depicted in FIGURES 1A and 1B where rapid thermal annealing is performed before plug formation. (*See e.g.*, Application Page 4, Lines 18-33). As such, Teo fails

to suggests subjecting the contact plug to a temperature sufficient to anneal the barrier layer, as recited in Claim 1. Moreover, for the same reasons discussed for the combination of Kim and Bai, Teo's teaching of annealing prior to the deposit of a metal layer, is contrary to Kim's goal of preventing the oxidation of the barrier layers, and therefore, the combination of Kim and Teo is also improper.

In summary, the combined teachings of Kim in view of Bai, or Kim in view of Bai and further in view of Teo, do not teach or suggest all elements of the present invention and are not properly combinable. This combination of references, therefore, fails to establish a *prima facie* case of obviousness with respect to independent Claim 1, as well as independent Claims 12 and 24, which contain analogous elements as Claim 1, or their respective dependent claims, under 35 U.S.C. §103(a). The Applicants therefore respectfully request the Examiner withdraw his rejection and allow Claims 1, 4-12, and 15-24.

II. Conclusion

In view of the foregoing remarks, the Applicants now see all of the Claims currently pending in this application to be in condition for allowance and therefore earnestly solicit a timely Notice of Allowance for Claims 1, 4-12 and 15-24.

The Applicants request the Examiner to telephone the undersigned attorney of record at (972)

480-8800 if such would further or expedite the prosecution of the present application.

Respectfully submitted,

HITT GAINES, P.C.

A handwritten signature in cursive script, appearing to read "Charles W. Gaines". The signature is written in dark ink on a white background.

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